This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

1837
ARTES
VERITAS
SCIENTIA
LIBRARY OF THE
UNIVERSITY OF MICHIGAN
E PLURIBUS UNUM
TUEBOR
SI QUAERIS PENINSULAM AMOENAM
CIRCUMSPICE

TN
443
.M5
E31

38
71800

COPPER MINING

IN LAKE SUPERIOR.

BY

PROF. T. EGLESTON, PH.D.,

SCHOOL OF MINES, COLUMBIA COLLEGE, NEW YORK CITY.

FROM VOL. VI. TRANSACTIONS OF THE AMERICAN INSTITUTE OF
MINING ENGINEERS.
ISSUED AT THE SECRETARY'S OFFICE, LAFAYETTE COLLEGE, EASTON, PA.

PRINTED FOR THE AUTHOR.
1878.

COPPER MINING

3875-7

IN LAKE SUPERIOR.

BY

PROF. T.homas EGLESTON, PH.D.,

SCHOOL OF MINES, COLUMBIA COLLEGE, NEW YORK CITY.

FROM VOL. VI. TRANSACTIONS OF THE AMERICAN INSTITUTE OF
MINING ENGINEERS.
ISSUED AT THE SECRETARY'S OFFICE, LAFAYETTE COLLEGE, EASTON, PA.

PRINTED FOR THE AUTHOR.
1878.

COPPER MINING ON LAKE SUPERIOR.

BY PROFESSOR T. EGLESTON, PH.D., SCHOOL OF MINES, COLUMBIA COLLEGE, NEW YORK CITY.

THE copper-bearing rocks of Lake Superior are composed of a series of metamorphic rocks, comprised under the names of amygdaloid and conglomerate, in which the copper and silver found with them are pseudomorphs. These rocks, generally, have well-defined walls which cause them to separate easily. Generally, the country rock is sterile, but it occasionally rises into the copper-bearing rock, and then carries copper. Usually, the amygdaloids carry copper, and the greenstones or melaphyres which encase them do not.

There is a very generally received opinion that the copper in these beds occurs in shoots. This does not appear to be proved, though the opinion seems to have some foundation from the experience of the Calumet & Hecla Mine, where a body of poor rock has been left, which, on the mine map, shows a general direction. The theory may be true of that individual mine, but too little work has been done in the other mines to draw any decided conclusion. The copper is very unequally disseminated in the rock, if any given piece be taken as an example, but, if the whole copper-bearing series be considered, its distribution is uniform. It may prove that there are certain directions in which the copper has been deposited more abundantly than in others, and these may be found to correspond with certain geological causes, but up to the present time the knowledge gained is not sufficient to warrant any general conclusion.

These rocks are supplemented by a series of true fissure veins, of which there are several systems, making the amount of native copper very large. Unfortunately, except in the fissure veins, known as "mass-mines," the copper is so scattered through the rock, and is in such a fine state of division, that, although it is not always difficult to mine, it is always difficult to dress it sufficiently to make it pay.

The metal is so uniformly distributed through these copper-bearing rocks that detached pieces, called "float," are found in digging on almost any land in the country. These pieces vary from very small fragments, weighing not more than a few ounces, up to many pounds. In one instance, in making an excavation for a cellar of a house, a piece weighing 1500 pounds was found. This copper is from 90 to 95 per cent., and, in detached pieces, even purer, and has evidently been deposited by electro-chemical action, having replaced parts of the rock, atom by atom. This phenomenon has taken place in all the different characters of deposits. I have had sections made of "barrel-work," from both the amygdaloid and conglomerate mines, which show the rock in all stages of impregnation. One from the Franklyn mine shows the copper in a leafy state, replacing the chlorite, so that when the chlorite not transformed is picked out the rock is nothing but a succession of hollow shells of copper. Not more than 40 per cent. of this mass was copper, and the rest was the more or less altered iron chlorite, known as delesseite. Another, from the Calumet & Hecla Mine showed the paste of the rock completely transformed into copper, leaving the crystals of quartz and feldspar intact. This piece was almost pure copper.

This condition of things characterizes the amygdaloid and conglomerate beds, and is in them in every possible stage of development, and gives rise, in both classes of rock, to very thin leaves which float on the water and are carried off in the process of dressing. The change of the rock into pure copper has not taken place to any great extent in these two kinds of veins.

The amount of copper in the rock varies from less than 1 per cent., as in the Atlantic, to 4 and 5 per cent., as in the Calumet & Hecla, which is the richest of all the mines; the yield of this mine for the year 1876 was 4⅗ per cent. mineral.

The strike and dip of the strata is very nearly uniform. At Portage Lake they have a strike of 35°, and a dip which is about 55°, which in the rest of the district rarely falls below 30°.

The amygdaloids vary but little in their constitution. They have been carefully studied by Professor Pumpelly,* and all the changes given in minute detail.

The conglomerates are found in every possible condition, from a type porphyry of large grain, with pebbles of from two to three inches in diameter, to a very fine-grained one, which is frequently transformed entirely into metallic copper. This rock, called the "sandslip," is from three inches to twelve inches thick in the Calumet & Hecla and the Alouez mines. At other times the whole rock is entirely decomposed into a hard clay, sufficiently plastic to be with difficulty compressed by the hand, but easily cut with a knife, retaining exactly the colors of the rock, and the shape and colors of the crystals of quartz and feldspar. In the vicinity of Portage Lake the conglomerates are entirely feldspathic, but from the Calumet & Hecla on they are highly quartziferous.

---

* Proceedings of the American Academy of Arts and Sciences, vol. xiii.

There is a theory that the conglomerates, when they are of fine grain, will be rich, which is not entirely to be depended upon. It is true that the finer the grain of the rock the more copper there will be likely to be in it, since the deposit seems to be more readily made in the paste of the rock, and for that reason a given cubic foot will contain more copper, since the larger pebbles are usually barren. Occasionally, the "sandslip," which is the conglomerate in the condition of very fine grains, is completely transformed into metallic copper, but this is an exception, as is also the transformation of the pebbles into copper. The fineness of the grain may be said to be a favorable indication, but the pillars of poor rock left in the mine are not usually of any coarser grain than those extracted.

There are fifteen different conglomerate beds, which are recognized by their position in the general geological section of the country, all but four of which have been found by explorations to continue through the whole of the copper region of the promontory of Lake Superior. All but five of these have had workings upon them, but the only paying mine on them is the Calumet & Hecla. They were formerly considered as barren of copper, and for a long time received no attention from mining men. At the Nonsuch Mine the copper is found in very thin flakes, scattered through a bed which is 14½ feet thick. This is divided into three sections: the upper one is 6½ feet, and is said to contain 1½ to 3 per cent. of copper; the middle one is slate, 5 feet thick, but poorer in copper; the lower one, 3 feet thick, contains 2 per cent. of copper, and carries pockets rich in silver. The mine has only just been opened, and although extensive preparations had been made to work it, they were brought to a standstill by the death of the president of the company.

The amount of copper contained in these rocks is very variable, but as the amygdaloid is easily crushed the selection is not very carefully made. An exceedingly poor rock, as at the Atlantic Mine, which yields only ⅞ per cent., can be worked. This is not true of the conglomerates which, on the contrary, are very hard. The rock must be richer, and the pieces have therefore to be carefully picked. The exceedingly favorable showing of the Atlantic, which is an amygdaloid mine, is owing partly to the fact that the ore is much more easily mined than in the conglomerate beds, but is also in part due to its excellent management.

All of these mines produce more or less copper in lumps, which, when of sufficient size to be handled, is called "barrel-work," to distinguish it from that produced by the stamps, which is called "stamp-work." These masses of copper vary from the size of a pea up. Masses weighing as high as one ton have been found in the conglomerate mines, but this is unusual. When slips have taken place in the hanging wall of these mines, the copper is deposited between the layers of the slips in thin sheets, which look as if they were rolled out. Many of them have been taken out from the Calumet & Hecla two feet square. They could probably have been taken out much larger but for the difficulty of handling them, for as it is not possible to separate all the rock, the sheet breaks or tears with its weight. It requires great judgment in the mine to determine what rock shall be brought to the surface and what left in the mine. The eye frequently fails to detect anything in the poor rocks, but by running the fingers gently over their surface, the miner soon learns to detect the slightly projecting pointed pieces of copper from the inequalities of the rock, and even to form an approximate judgment of how much it contains.

The methods of mining which will be described are, those of the ancients, which will be passed over with only a notice; those used in the fissure veins, or "mass mines," and those used on the amygdaloid and conglomerate beds.

The disposition of the copper in the mines causes several kinds of material to be sent to the smelting works: "mass copper" is the large pieces, from fifty pounds and upwards; "barrel-work" comprises the pieces less than about fifty pounds, which can be easily packed in barrels; "stamp-work," or "mineral," is that which comes from the dressing works. All the mines produce mineral and barrel-work. Mass copper comes, except occasionally, from the mass mines. The conglomerates produce but a small amount of barrel-work, while the mass mines produce a great deal. As all the mines produce mineral, it is by far the largest part of the copper treated in the smelting works.

The organization of the mines is generally the same throughout the district. It is usually arranged so as to separate the surface work from the mining proper, and differs only in non-essentials from one district to the other, in different mines. The chief man is the agent, who is responsible directly to the board of directors. Under him are three officers, the head mining captain, the surface superintendent, or "surface boss," as he is generally called, and a physician. In a few exceptional cases, the head captain is, to some extent, independent of the agent, but this is not generally so. The agent makes all the contracts for supplies, and purchases all the materials for the mine. He conducts all the business of the office, having under him a force of clerks, more or less large, according to the business of the mine. Sometimes the surface contracts are made by the superintendent, but always with the approval of the agent. In the office the mining and surface work are always kept separate. The mine clerk has charge of all the books relating to the mine proper, keeps all the accounts of the mine contracts and a personal ledger account with each miner. These accounts, less the store charges, are settled once a month in drafts, which the men negotiate. Generally, very little money is kept at the mine, both on account of want of security, and because it is quite as easy for the men to negotiate their drafts as for the company to get the ready money. A miner desirous of leaving before the end of the month sells his verified account easily. In mines with full credit such an account will bring very nearly its face. They are, however, sometimes sold at a great reduction, when the credit is not good or a panic takes possession of the men.

The surface superintendent has under him a master mechanic or machinist, a head blacksmith, and a head carpenter, who have charge of the machinery, tools, buildings, and all the work of the mine, not immediately connected with mining. They take charge of all the ordinary repairs to the machinery and tools, cut and saw the timber, build and repair the houses, take care of the surface railroad, etc.

In some mines, in addition to these men, there is a farmer, who raises produce on the company's lands; but generally it costs more to raise crops than to purchase them in the open market. The store at which the men purchase their supplies is either kept by the company or let out by contract, with the agreement that the store accounts shall always be secured by the company to the store, and have preference over all other debts owed by the men.

The prices charged are reasonable, and are generally as low or lower than the men could obtain elsewhere. The men are not obliged to go to the store, though most of them do.

The companies generally own houses, which they let to the men with families at a low rent; some of these families take boarders, but most of the single men prefer to live in boarding-houses, which at some of the mines are kept by persons licensed by the company.

The houses let to families generally have a garden plot attached to them, which helps to keep the men quiet, as no one will give up a garden until he has reaped the full benefit of it.

Every large mine has at least one physician, who receives a salary. A certain sum is deducted from the pay of the men, each month, toward this object. This is generally double for men of family what it is for single men. Sometimes two or more mines employ the same physician, if they are within convenient riding distance the one from the other.

The head mining captain has entire charge of the underground workings. He is generally responsible to the agent, but sometimes to the company. He usually has under him at least two other captains, one for the day and one for the night shift, who work alternate weeks on the day and night shift.

The miners generally work by contract, usually on short times, but the arrangement is a nominal one, for the contracts are made so that only a certain minimum per month shall be earned. If it is found that more is being made, the price of the next set of contracts is lowered. The head mining captain lets the contracts on his judgment of the rock, generally made by sounding it with the head of a pick; judging by the sound how firm the rock is, he lets the contract according to its solidity and the ease with which, according to its position, it can be detached. This letting of contracts requires not only experience but great judgment on the part of the officer, but the company always has control of the matter, for if by the books at the end of the month it is seen that the mining captain has made a wrong estimate, the price is lowered at the next letting. The contractor selects his own men and works in partnership with them. They receive their mine supplies from the mine, and are charged with them. The steel is weighed at the commencement and the end of the contract, but the mine blacksmith does the sharpening at the expense of the mine. When the contract is finished it is measured by the head captain, or one of the captains, and reported to the clerk, who accepts the captain's report as correct and credits the amount due each man on the company's books, subject to reclamations, which in dull times are not often made. The hours vary according to circumstances. The shift is generally twelve hours, but for work of a special nature eight-hour shifts are made. In most of the fissure veins very careful mine surveys are made and kept up, so that the map is a record of all the accidents to the vein which have been shown in the mining. In many of the other mines the mine map is simply a plan of the foot-wall, which serves no other purpose than to give a general idea of the progress of the mine.

ANCIENT MINING.

Mining in the copper region of Lake Superior has been carried on from a very remote period, dating at the least five hundred years before the discovery of this country. This date is assigned from the age of trees which have grown over the explorations. The methods used by the miners of that time were very rude; they simply followed the vein matter with copper tools and stone hammers, using wooden shovels to move the broken rock, and wooden bowls and bark launders to free the mine from water. They did not want, and were unable to handle, pieces larger than a few pounds, which they took as they found them and beat out cold into shape, leaving the silver attached to the copper. They seem to have had no knowledge of dressing, which would have been of no use to them, as they were ignorant of the fact that copper could be smelted. Their excavations were usually open to the air, and never more than twenty to thirty feet deep; in a few instances only was any rock left overhead. They generally followed the outcrop of the vein, but made no attempt to follow it in depth. Most of their excavations were so filled by decayed trees and dirt, that in a thickly-wooded country they for a very long time escaped observation. When attention was once called to them they were explored, and many of the best mines in the early history of the present development were located upon them. This is true of the Central, in the Keewenaw district, where three large masses were found uncovered, two of them overlapping each other, amounting to 53 tons in weight. The thin edges of these overlapping masses had been hammered so that they were very much bent before it was decided to abandon them. At the Minnesota mine, in the Ontonagon district, they found a mass of six tons, which had been raised on a cobwork of wood several feet before it was abandoned. The wood was still sound, but when brought to the air it cracked and rapidly went to pieces.

The veins worked by these miners were not chosen at random, but were selected with a judgment and skill to which the prosperity of some of our mines of to-day are to a great extent due. Nothing is known of the people who did the work, except the scanty traces which they have left behind them in the mines, all of which seem to have been abandoned in the full tide of prosperity, and are left as though it was evidently the intention of the people to return to them. From the methods adopted and the severity of the climate, it is evident that they were mined only in the summer season, for in a country where the average depth of snow is from four to five feet, such workings would have been impossible in the winter. Who these ancient miners were, or where they lived during the rest of the year, we can only conjecture. All that is known of them was published in the early volumes of the *Smithsonian Contributions to Knowledge.* Personal inspection of many of their works show them to have been a people of a certain amount of civilization. They had an art of hardening copper, probably by hammering it cold, and a skill in using their tools, which makes us wish that we knew more of this race of miners.

MASS MINING.

The masses of native copper which are found in the mass mines vary very greatly in size. They are sometimes single masses and sometimes a succession of masses, held together by thin sheets or threads, and sometimes masses properly speaking. Most of the mines which have produced the largest masses are in the Ontonagon district. One was found in the Minnesota mine which weighed five hundred tons; one in the National, which, if it had all been got out together, would have weighed over one thousand tons, but the nature of the ground was such that it was cut up to extract it, and mined at different times. In the Keweenaw district the Central has produced several masses weighing over three hundred tons each; the Phœnix one of six hundred tons, and many over one hundred tons; the Cliff several of one hundred and fifty tons each. These are very large masses, and are only found occasionally. The average of those extracted will not weigh more than one to fifteen tons.

To mine such large quantities of metallic copper is very difficult, and to get them into a shape to use commercially is still more so. They are sometimes from ten to twenty or even fifty feet in length, from ten to twenty-five feet in width, and from an inch or less in thickness on their edges to five or six feet.

The masses are often discovered by what are called "horns." These horns are projections of native copper, which are generally, to commence with, not much larger than the thumb, which protrudes from one of the walls of the vein. When such a projection as this is found it is usual to explore it to find out its extent. But many very large masses of copper carry no horns, and are consequently smooth on their surface and give no indication of their presence, so that systematic methods must be used. The usual method of mining in mass veins is to run a drift on the hanging wall of the vein from ten to twenty feet or more in length, and then take out the whole of the vein matter, the rock of which is sorted; but the larger part goes to the stamps to be crushed and concentrated.

This work is much more difficult than it would at first sight appear, on account of the fact that the surface of a mass is often not only very uneven, but is frequently attached to the rock by strings which vary in size, and are often larger than the arm. The masses vary greatly in thickness also, and sometimes appear to be a large number of masses joined together by sheets or strings, which are often so thin as to be easily cut through by a blow of the pick. The vein must be systematically explored by endeavoring to drill across it, at very short intervals above and below, for ten or twenty feet or more, stopping when copper is reached, until the drill, going deep into the vein matter, shows that an edge of the mass, or a thin spot in it, has been reached. This hole is blasted. If the mass is not very large or thick, although the copper is not thrown down, a crack is made. This crack is then tamped tight, filled with powder and fired. This is repeated until an opening large enough to introduce five to ten kegs of powder is made.

This method is, however, applicable only to small masses much mixed with rock. When the copper is thick it will not answer, and it is necessary, then, to drill behind and blast so as to crush the rock and make a place for the powder. In drilling these holes for blasting out the vein matter, if the drill strikes copper before the hole is deep enough to blast, another hole is drilled a few feet further on. If this strikes copper, holes 1½″ in diameter are drilled on all sides to the number of twenty or more, the whole length of the vein as it stands. This locates the mass. The miners then go back to the place where the vein was last blasted out, and with drills, 2½″ to 2¾″ in diameter, and from 4′ to 7′ long, try to get behind the mass. These holes are filled ¾ full of powder, tamped with fine stuff, rammed as tight as possible, and then fired. If this does not throw the rock, it is certain that there is a mass more or less large to be dealt with. Very often the holes which have been fired, although they do not throw down the copper, crush the rock behind it, so that with sharp-pointed bars an opening sufficient to introduce one or two kegs of powder can be made. If this does not throw the copper down, it is left in place until stoping uncovers more of it, and the drift is pushed forward. When ready, a stope four feet six inches high is carried on the hanging wall and the rock levelled. The vein stuff so removed is sent to the "mills" to be carried to the stamps.

When the masses are very large these methods are not applicable. The face of the mass is then disengaged as before, and a small drift is run on the foot-wall so as to disengage a certain portion of the back. This tunnel is not carried to the full extent of the length of the mass. This exploration having been finished, the depth of the copper in the middle will be known, and its weight can be approximately told and the charge of powder determined. In making this tunnel the copper is followed where the mass is thick enough, but where it thins out some rock is left as a security against blowing out at that point. Exactly how this work is to be done must be determined in each individual case. If the mass is of moderate size, and the hanging rock is strong and requires no timbering, the whole mass may be uncovered and blown down at one time. If, however, the mass is a very large one, and the hanging wall requires support, it may not be expedient to remove more than a small fraction at once. In such conditions it requires a great deal of judgment to determine what is to be done. When the drift is ready, it is charged with powder and its mouth closed with sand or sand-bags, tamped tight with sand and clay, and fired. The amount of powder used will depend not so much on the size and apparent strength of the mass as on the conditions under which it is found, and on the nature of the rock. It will generally be from five to twenty-five kegs. As the firing of such a quantity of powder will render the air thick for some time, no matter how good the ventilation may be, this work is done usually on Saturday evening when the last shift comes up. By Monday morning the air will be good again. A seventy ton mass in the Phœnix Mine was thrown down with twelve kegs in August, 1876; but there can be no general rule laid down. It is a serious matter to determine the amount, for if the powder is not in sufficient quantity to throw the rock, it may do serious damage. Captain Parnell cited to me an instance in the National Mine where five kegs of powder were used on the fourth level, two hundred feet from the shaft, which, when exploded, proved insufficient to detach the mass, but threw over the men in a drift one hundred and fifty feet distant, bruising them badly, and threw off the boards of the shaft-house at the surface. Powder is always used; other explosives, though more powerful, are not in favor, and therefore do not succeed so well.

The powder will either disengage the mass entirely, or loosen it so that the rock at the edges may be disengaged by picks or bars. When free the mass falls into the position which has been assigned to it. Sometimes an excavation has to be made into which the mass may fall, so that there may be perfect ease and freedom of movement in cutting it up. This is, however, not generally done until it has been blown down and every means has been resorted to to reduce the mass to small pieces without it. Often the sand-blast has shaken the mass and the rock attached to it so much, that by block-holing and cutting off small pieces here and there, the size is reduced at very small expense, so that the cutters can work without having any room prepared. Sometimes a second sand-blast is put in before going to the expense of blasting for room, but when the mass is solid, the rock around it must be blasted out until the men can swing their hammers easily. When this place has been prepared the mass is raised by jack-screws and propped up with billets of wood, so as to be in a convenient position to be cleaned from rock with picks, as far as practicable, in order to be cut up. When sufficiently clean, it is delivered to the cutters, a party of three men, two striking and one holding the chisel, which is sharpened both ways in the direction of its width, which is generally half an inch; its thickness is generally one and a half inches.

The bit is fifteen-sixeenths of an inch wide, and is bevelled both ways. As the chisel has to be turned when a chip is taken out, it is necessary to use great care in getting the corners of the bit of equal distance from the centre of the chisel, so that it will always cut the same distance from the centre of the cut, and keep it perfectly straight. If the chisel was made like an ordinary chisel the difficulty of getting the two corners of exactly the same temper would be very greatly increased, as would also the difficulty of cutting. These chisels vary from one to six feet in length, depending on the thickness of the mass. Six feet is an unusual length, but was used on a six hundred ton mass found in the Phœnix mine in 1869. The usual length is not over five feet; the general rule is to make the chisels 18″ longer than the thickness through which they are to cut. The sledges which are used weigh seven pounds and the handles one and a half pounds; the total weight is thus eight and a half pounds. The handle is 2 feet 6 inches long; the head is generally 5½ inches long and 2⅛ thick, it rounds from the centre of the head to the face, which is one inch square; the helve opening is 2 by ⅞ inches. The hammers were formerly very much heavier, the head weighing as much as ten and twelve pounds, but it was found that not as much work could be done with the heavy as with the lighter one. A hammer of the same weight is used for drilling the rock as for cutting the copper. The mass is first lined off so as to be cut up into pieces of a convenient size for handling in the mine. The size of these masses is regulated by the smelters, who require that they shall be of such dimensions as to be easily charged in their furnaces. Pieces as heavy as fourteen tons, cut from the six hundred ton mass, have been sent from the Phœnix Mine, but that is unusually large. If, however, by cutting off a few pieces a mass of eight or ten tons is left, it is sent to the smelting works. This saves a large amount of cutting. Generally, however, the pieces sent from the mines will weigh between two and eight tons. As the pieces are cut off they are moved with winches and tackles to the "mills," and let down to the levels to be removed to the surface. Very large pieces are hoisted through the shaft with a heavy rope kept for this purpose. At the Phœnix Mine it is of hemp, 5″ in diameter.

When the parts to be cut off are determined, the workmen commence with a short chisel, its length depending upon the thickness of the mass at that particular point, and cut out a band of copper the width of the chisel, and about one-eighth of an inch thick through the whole thickness of the mass. The cut is to go through and across the mass in a perfectly straight line. After the cut is about six inches in length it will generally be so deep that it will be impossible to see below it, and for this reason the mass is always raised and a candle placed just at the bottom of the slit, so that the workmen may see what they are doing. The time that will be taken in cutting up such a mass will depend upon its thickness. The work is exceedingly difficult, and is a severe strain upon the endurance of the men. To avoid the shock and to protect his hands the holder usually wears a heavy mitten. It does not require so much strength as skill to keep the chisel constantly at the angle which will cut the copper. This angle is learned by experience, and although it is always the same, a green hand will often fail to cause his chisel to cut, or make it cut out. The men work their full shift, but it is generally conceded that the holder, although he must be very skilful, has the easiest work. The holder takes good care to see that when they are near the end of a chip a block of wood is placed under the cut, so that the head of the chisel, when it cuts through, shall not fall upon his hand, or the point of the chisel be dulled by striking a hard substance. Not infrequently two or more parties work on the same mass; they usually work eight hour shifts. In cutting up the five hundred ton mass at the Minnesota mine, there were as many as nine parties cutting each shift, or eighty-one men in twenty-four hours. Such a number could only work at first, for as the outer cuts were finished the parties had to be removed, but a large force can always be kept employed on a very large mass until it is entirely cut up. The quantity that three men can cut in a day will generally be about three-quarters of a foot, which, supposing the mass to be one foot thick, would bring the cut back nine inches. The contracts are let by the foot. When the miners' wages are about $50, the contracts are let at $12 per foot, the miners furnishing their own lights. Skilled men will make about $2.50 per day at that price. The responsible man in the work is the holder; the amount of work done in a day depends almost entirely upon him. A good chisel-holder is an expert, and consequently a difficult man to get; under him the strikers work hard, but accomplish a great deal. A poor holder will make the strikers work quite as hard, but they will make very little progress in the cutting. A good holder, while he keeps the strikers in constant activity, will carry no more on his chisel than they can keep constantly driving. He will keep his cut perfectly straight from the top to the bottom, so that there will be no shouldering on the side, or digs into the mass. A poor holder will have too light a chip, in which case the chisel will be out before it is halfway through the cut, or too heavy a one, in which case the work of the strikers is greatly increased without its efficiency being as great as with the proper depth of chip. It was formerly the practice to make the chip of equal thickness; they are now made feather-edged or wedge-shaped. This is much easier on the strikers, requiring much lighter blows, and is much more effective. A good holder will take a chip out of both sides of the cut, and then run his chisel through the centre and take out the ridge in the middle. The cut is in this way made a little larger than the chisel, and if, by accident, he should cut out, he can take it up where he left off, whereas, by the old method, he would have to go back to the beginning.

The time which is required to disengage and cut up a large mass is so great that it usually costs as much, or more, to get it out of the mine as it would to stamp the same weight of copper from a low-grade rock. The five hundred ton mass of the old Minnesota Mine required eighteen months' constant work before it was all removed from the mine. An ordinary mass of fifty to sixty tons will require the labor of three men, working at it continuously, for from three to four months, before it is ready to come to the surface. Once extracted, the mass is still not in condition to go to the smelting works, as it is associated with a large quantity of rock, which is chiefly calcite. In order to get rid of as much of this as possible, the pieces are placed together in kilns, and fired with wood so as to heat the copper to quite a high heat, and are then extinguished with water. In this way the rock becomes very friable, and is picked off with picks and tools made for the purpose. It is for the interest of the proprietors to clean the copper as much as possible, since all that is sent to the smelting works is weighed as copper, and is paid for as such.

The pick which is used is the ordinary miner's pick, which is made with a pall or head on one side, to be used in driving gads or wedges. From the point to the eye it is 11 inches. The eye is 2⅛ by ⅞ inches; the head is 3 inches long and 1¼ square on its face. The pick weighs 4½ pounds. The handle is 2 feet 6 inches long and 1½ inches at the end, and weighs 1½ pounds.

CONGLOMERATE AND AMYGDALOID MINING.

The system of mining differs from the foregoing but little except in the first layout of the mine. In the conglomerate and amygdaloid mines shafts are sunk in the copper-bearing rock, the number depending on the size of the mine. The Calumet has eight, the Allouez and the Osceola three each. The distances between them vary from three hundred to eight hundred or nine hundred feet. Heavy walls should always be left on the sides of this shaft, but it has not always been done, and the want of them will always be a source of increasing expense to the companies who have made the mistake. Levels are then laid off from the shaft, generally ninety, but sometimes one hundred feet apart, which connect the shafts. Generally, the levels are twelve feet by twelve feet, but their height depends on their finding an easy and secure separation to form the roof. Sometimes the thickness and richness of the bed are sufficient to allow of the whole of it being worked at once, as in the Calumet & Hecla. At others, only part of the bed is worked, as at the Allouez, where the bed is twenty-six feet thick, but only twelve feet of it is worked. To facilitate the driving of levels winzes are sunk between the shafts. In the fissure veins the shafts, sometimes vertical, sometimes inclined, are not generally sunk on the vein, and the levels and stopes are made usually in the hanging wall. The shafts are usually twelve feet wide by six feet high, and are divided into two parts by a 2″ plank partition. One of these serves for the extraction of the ore, and the other for the passage of the pump and the men. The levels are always run so as to convey the water to a single sump at the foot of one of the shafts. The mines are not, however, very wet. For those of ordinary size, a small pump, working only part of a day, will keep the mine dry when the ground has not been affected by caves which let in the surface water.

The method of mining is overhead-stoping, which is done by hand or compressed-air drills, according to the situation of the place to be worked. As soon as the mine is opened the rock is extracted at once, commencing from the shafts and winzes, working both sides of them. If the rock next the shaft does not contain copper it is left, but otherwise it is taken out. The roof must be then supported by timbers. No attempt is usually made to fill up the space left by what is taken out of the mine, unless the material to do it with is close at hand. In the bed called the "Ashbed," at the Copper Falls Mine, immense chambers, seventy-five feet square, have been left without any support of any kind. The roof is very firm and has stood for many years, but there is no excuse for such methods, for eventually the roof must yield. The result in the Minnesota Mine is, that if the mine were pumped out there is little probability that it could be worked. If pillars had been left, the mine would probably have still been capable of being put in working order. The result of the system is that that mine now can only be worked on a very small scale. There must come a time when the wooden props will crush, and then the future of the mine will be compromised, even supposing that the shaft or level is kept in order. If a timber be replaced, it must be every time shorter, as the roof descends the surface-water is let in, and constant expense of repairs necessary, as witness some of the first levels of the Calumet & Hecla. After a certain time the opening will be either too low to work in, or the roof must be taken out, a hazardous and expensive operation in yielding ground. If the proper pillars had been left, the workings would have remained good for years.

Each company is obliged to own woodland and to select the best of their wood for supports, or, as is the case of the Calumet, go long distances, and raft their wood. The method is otherwise bad, as when the ground begins to crack, the superficial waters must come in. The present inconvenience is not great, as the roofs are generally very solid, but on account of the use of this method, any attempt made to work on a large scale the Minnesota Mine, which has lain idle a number of years, would to-day probably prove a failure.

In looking at the vast chambers in many of the mines without any support of any kind, one has an involuntary feeling of dread lest the roof should cave. The solidity of the ground is remarkable, but it must one day give way. The immense amount of rock which has been thrown on the burrows, suggests the advisability of filling the old workings of the mine with it, and this has sometimes been done in a very limited way. If it had been adopted as a policy at the commencement of mining operations, much would have been saved by it. Generally, the roof is so solid in the conglomerate, that no support of any kind is needed in the ordinary stopes, but occasionally the hanging-wall is insecure from slips, which have made the rock friable, with large cleavage planes; the roof must then be supported. This is done with heavy timbers, which in the Calumet & Hecla mines are sometimes two to three feet in diameter and are placed almost in contact.

The stopes always have communication with the levels below. To make this, heavy timbers are footed into the foot-wall, and dropped against the hanging-wall, at an angle of about 45° from the plane of the level. In the Phœnix Mine they are placed six feet from centre to centre. Every ninth timber is placed a little further apart, and the space between laid out as a "mill," which is carried up with the stope, so that every stope has one or more mills. These mills are 7 feet by 5 feet.

The drills which are used for soft rock are made of one-inch octagon steel, the bit of which is forged to 1½ inches. In the conglomerate the bit is forged to only 1⅛ inches. One man holds while two strike. A one-man drill is rarely used, except in block-holing, or in preparing the places for the heavy timbers to support the walls.

Cartridges are not used, though they would save much time, and allow of much more work being done. The use of fuses is universal. Three men will easily make three holes of 2 feet to 2 feet 6 inches in a shift of eight hours in moderately hard rock. In conglomerate they cannot do anything like as much. Wherever it is possible, compressed-air drills, generally of the Burleigh or Winchester patterns, are made use of, but a large amount of hand-work has always to be done. Powder is used exclusively in blasting. The miners do not like dynamite, nor any of the modern explosives, as they say the air after a shot gives them a headache. The shots are fired, as much as possible, at the end of a shift, so as to give the air time to clear before the other shift comes on.

The pick which is used is the same as the one described as being used in the mass mines. It has on one side the pick, and on the other the head or pall, which is tempered to drive a "gad," or steel wedge. It is also also used to sound the rock and ascertain its solidity.

The number of men and their wages, employed at the Central, a mass mine, is given below:

	1875.	1877.		1875.	1877.
Miners, . .	158	195	Wages per month,	$52.65	$49.80
Surface men, .	39	35	" "	43.14	40.43
Stamp men, .	15	12	" "	44.57	47.02

There were in the Allouez Mine, in July, 1876, 282 men in 24 hours. They worked 10 hours to a shift; from 7 A.M. to 6 P.M., a day-shift, and from 7 P.M. to 6 A.M., a night shift. There were 122 men stoping, 42 drifting, 18 sinking.

There were three rock-drilling machines, with six men on each, making for the machines eighteen men; thirty trammers, who wheel the rock; twelve block-holers, who split or fire the rock; eight landers and bell-ringers; four timbermen and helpers; sixteen laborers, and three mining captains.

The average number of men in the mine throughout the year was 318 per month. The average wages of the men, including mining captains, was $47.10. These costs include the cost of hoisting and pumping. The total cost of these men and the number of days' work done, in the Allouez Mine, for July and August, 1876, by each class of men, is given in the table below:

NUMBER OF MEN EMPLOYED BY THE ALLOUEZ MINING CO. IN THE MONTHS OF JULY, 1876, AND AUGUST, 1876.

Miners on Contract, ...	175	183
Mining Captains, ...	3	3
Miners, ...	20¼	16
Machinists and Helpers, ...	6⅝	7⅜
Carpenters, ...	6⅞	9
Timbermen, ...	2	2
Laborers and Teamsters, ...	70⅛	86½
Firemen, ...	9¼	9⅞
Blacksmiths and Helpers, ...	7⅞	8½
Framers of Skips, ...	36	35½
Landers and Bellringers, ...	8	8
Engineers, ...	7¼	7⅝
Foremen, ...	3	3
Surface Captains, ...	1	1
Watchmen, ...	2⅜	2⅜
Masons, ...	2	1
Brakemen, ...	1	1
Trackmen, ...	5⅜	1
Agents and Clerks, ...	3	3
Head Runners, ...	2⅛	2¼
Stamp Feeders, ...	6⅞	7¼
Dressers, ...	17	18¾
Total, ...	396	417

The following table gives the cost of wages per ton of rock hoisted, and per ton of rock milled, at this mine, for July and August, 1876.

MINERS' WAGES AT THE ALLOUEZ MINES.

JULY, 1876.

	NUMBER OF DAYS' WORK PER TON OF ROCK.		COST PER TON OF ROCK.	
	Hoisted.	Milled.	Hoisted.	Milled.
Mining Captains,	0.0115	0.0159	$0.0500	$0.0691
Miners,	0.0780	0.1080	0.1153	0.1596
Machinists and Helpers,	0.0115	0.0159	0.0246	0.0343
Carpenters,	0.0078	0.0108	0.0175	0.0243
Timbermen,	0.0078	0.0108	0.0171	0.0237
Laborers,	0.0491	0.0680	0.0650	0.0900
Firemen,	0.0038	0.0053	0.0057	0.0078
Blacksmith and Helpers,	0.0154	0.0213	0.0367	0.0507
Framing Skips,	0.1387	0.1920	0.1909	0.2643
Supplies Used,			0.1378	0.1907
Total,	0.3241	0.4484	$0.6608	$0.9145

AUGUST, 1876.

	NUMBER OF DAYS' WORK PER TON OF ROCK.		COST PER TON OF ROCK.	
	Hoisted.	Milled.	Hoisted.	Milled.
Mining Captains,	0.0111	0.0151	$0.0481	$0.0656
Miners,	0.0594	0.0811	0.0888	0.1212
Machinists and Helpers,	0.0139	0.0190	0.0276	0.0376
Carpenters,	0.0037	0.0050	0.0058	0.0079
Timbermen,	0.0074	0.0101	0.0165	0.0225
Laborers,	0.0788	0.1075	0.1038	0.1416
Firemen,	0.0046	0.0063	0.0069	0.0094
Blacksmith and Helpers,	0.0157	0.0214	0.0386	0.0527
Framing Skips,	0.1318	0.1798	0.1835	0.2504
Supplies Used,			0.1482	0.2022
Total,	0.3267	0.4453	$0.6679	$0.9114

The cost of work in the Allouez Mine in August, 1876, per foot, was:

Drifting in 1875 and 1876, averaged,	$19.00
Drifting in conglomerate, with no foot,	35.00
Drifting in conglomerate, with a foot,	$18.00 to 20.00
Drifting on hanging-wall would cost about,	6.00
Drifting in winzes,*	17.00 to 23.00
Drifting in No. 2 shaft,	37.00
Stoping from No. 2 shaft, per fathom,	20.00 to 23.00
Sinking No. 3 shaft,	50.00
Sinking in 7th level,	25.00
Sinking in 6th level,	20.00
Sinking No. 1 shaft, in broken ground,	32.00
Sinking No. 2 shaft, for top,	30.00
Sinking No. 2 shaft, for middle,	34.00
Sinking No. 2 shaft for bottom,	36.00
Average, for sinking shafts,	33.30

---

* *If the* winze had no foot it would not be sunk.

The cost of mining at the Central is given below:

	1875.	1877.
Sinking in shafts and winzes, ...	$32.88	$33.60
Drifting on the vein, ...	12.07	11.53
Drifting on the conglomerate, ...	18.81	13.47
Stoping on the vein, per cubic fathom, . . .	19 40	20.73
Stoping on the conglomerate, ...	32.45	21.70

The following table gives the cost of mining at several different mines:

COST OF MINING.

	Atlantic. 1876.	Atlantic. 1877.	Nonsuch. 1876.	Quincy. 1877.
Stoping, per cubic fathom, . . .	$17 23	$16.24		$17.29
Drifting, per foot, ...	12.58	11 83	$7 00	11.22
Sinking, per foot, ...	30.00	36.00	12.00	13.44

The average number of contracts at the Allouez was 218, and the average wages of the contractors was $47.85. The following table gives the cost of mining, per ton of rock hoisted, and per ton of rock milled, at this mine, for July and August, 1876.

COST OF MINING AT THE ALLOUEZ MINE.
JULY, 1876.

DISTANCE.	Price per foot or fathom.	Number of Men.	Cost per ton, Hoisted.	Cost per ton, Milled.
Sinking Shaft, ...				
" Winzes, 48.5 feet, . .	$13.75	12	$0.1082	$0.1495
Drifting, 62.3 feet, ...	19.35	24	0.1776	0.2458
Stoping, 371.96 fathoms, . .	18.54	121	0.9845	1.3626
Cutting Plats, Casing and Dividing Shaft, and Blasting outside of level, ...		18	0.1084	0.1501
Cutting Fork, ...				
Miners' Wages and Supplies, .			0.6608	0.9145
Total Mining Cost, ...			$2.0395	$2.8227
Powder, Fuse, Candles, Steel, etc., included in items above, ...			$0.3044	$0.4213

AUGUST, 1876.

DISTANCE.	Price per foot or fathom.	Number of Men.	Cost per ton, Hoisted.	Cost per ton, Milled.
Sinking Shaft, 5 feet, ...	$30.00	3	$0.0206	$0.0281
" Winzes, 21 feet, . . .	17.00	6	0.0532	0.0726
Drifting, 131.2 feet,.	19.74	42	0.3136	0.4279
Stoping, 369.63 fathoms,. . .	18.96	129	0.9715	1.3257
Cutting Plats, Casing and Dividing Shaft, and Blasting outside of level, ...				
Cutting Fork, 11 feet, ...	20.00	3	0.0302	0.0412
Miners' Wages and Supplies, .			0.6679	0.9114
Total Mining Cost, ...			$2.0571	$2.8070
Powder, Fuse, Candles, Steel, etc., included in items above, ...			$0.3343	$0.4562

The lighting of the mines is done exclusively by candles, which are surrounded by a lump of clay, and attached to the hat while walking, or to the wall when at work; they weigh about 1.5 ounces each. Four or five are burned during a shift. They are never burned out entirely. The ends are carefully saved, and in some mines are used to fire the fuses. The use of candles is universal. It would seem as though there would be an advantage in using oil, so far as the cost of lighting is concerned, but the habit of using them, and the convenience of attaching the candle anywhere with the lumps of clay, overcomes any advantage of economy which the oil might have.

The entry to the mines is usually by ladders, which are placed on the foot-wall. These ladders are made with wooden sides and wooden or iron rounds. Those with wooden rounds are made by contract at $0.06 per running foot. They are much easier to use than those with iron rounds, which, however, last much longer. As the incline of these ladders is about that of an ordinary stairs, they are not infrequently provided with a handrail, and used as stairs or ladder by the men as each one fancies. This has led in some of the mines, as in the Phœnix and Nonsuch, to the use of stairs, which are made of pieces of plank, fastened securely to the foot-wall with pieces of wood nailed on in such a way as to make a step eight inches wide, with a rise of ten inches. The wood for making the riser is only four inches wide, so that the beam shows under it. Such steps cost $0.10 per running foot, and are very easy to walk on. They last more than three times as long as the ladders, without repairs, which, when necessary are less expensive, and more quickly made, than those to the ladders, and, as the main beam does not have to be removed, can be very rapidly made. At the Phœnix, and formerly at the Central mines, the men are let into and taken out of the mine on a large step-car, thus saving the men, when the shifts are long, a great deal of time and fatigue. The Calumet & Hecla and the Central have man-engines; the one in the Calumet does not reach to the bottom of the mine, but goes only part of the way.

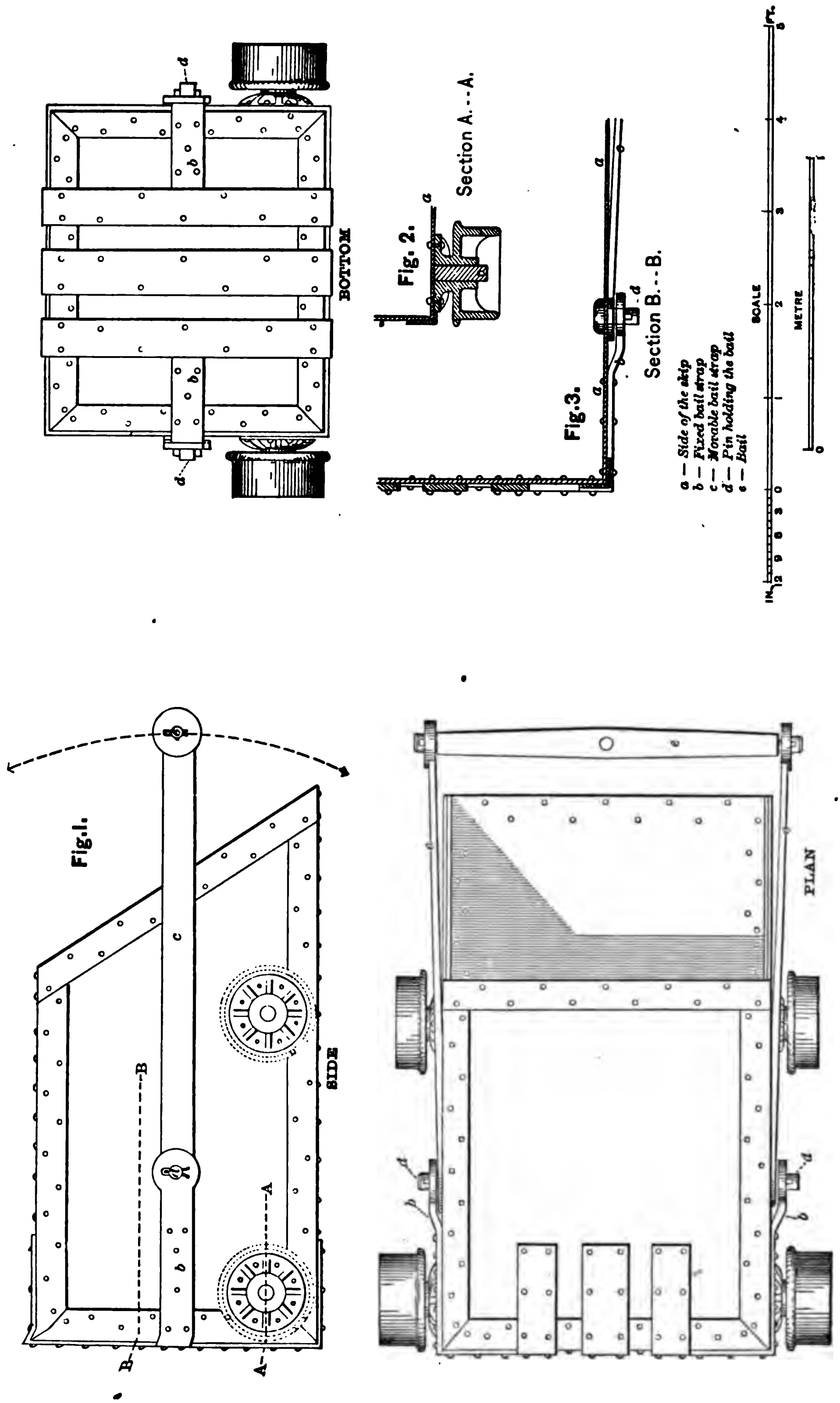
The rock is picked as much as possible in the mines, for which reason the very large pieces in the conglomerate mines are always block-holed and blasted in the mine until they are sufficiently small to be transported in the skip. The poor rock is left in the mine and is thrown against the stulls. The difficulty of selection in the mine, however, is such, that most of the rock is carried to the surface.

The first selection in the amygdaloid is made in the shaft-house. The rock is piled on a wagon and carried to the shaft; the skip is let down, so that the sides reach below the bottom of the rail; the rock is dumped into it and the signal given for hoisting by the signal-man who stands at the foot of the shaft. Another signal-man is stationed at the top of the shaft to give notice of the approach of the skip. This position requires a man of activity and intelligence, as any failure on his part to give the signal would cause the skip to go to the top, where it would be caught by the turn of the rails and the cable pulled in two. This accident happened twice in the course of ten days in one of the mines, breaking the iron rope and letting the skip down a distance of seven hundred feet, from which it came up with but few bruises, the greatest being the breaking of the cast-iron boss by which the axles are attached to the sides. The wood-work of the shaft was very much damaged, but fortunately no lives were lost.

The skips are made of half-inch rolled iron, riveted at the corners to angle-irons four inches wide by half an inch thick. Fig. 1 gives the details of the skip at the Atlantic Mine. The bottom is seventy-two inches long. It is thirty-six inches high and forty-two inches wide. The top is bevelled to the angle of the inclination of the shaft, so that it is only forty-eight inches long. The back is reinforced by three strips, one inch thick, the whole height of the skip, which are three inches apart. The middle one is six inches wide, and the side ones are five inches.

The wheels are thirty-six inches apart, the hind ones being placed as near the back as possible. The wheels are twelve inches in diameter, the hind ones having a tread of five inches, while the front ones have one of only three inches, so that when it rises to the top it will fall through the tramway and let out the ore, while the hind ones are caught in curves of the rails. The axles are made of steel, two inches in diameter and five inches long, and are fastened in cast-iron bosses (Fig. 2), two inches thick and ten inches in diameter, which are riveted to the sides.

The skip is hoisted by a movable bail strap, c, four inches wide, and seven-eighths of an inch thick, which rotates on a pin, d (Fig. 3), which passes through the side of the skip, a, and through the fixed bail-strap, b. The movable bail thus rotates between a and b. The bail-strap is fifty-seven inches long from its point of rotation to where it is attached to the bail. The bail, e (Fig. 1), is forty-five inches long, four inches wide, and two inches thick, and is slightly wider in the middle, where the hole for the attachment of the rope



MINE SKIP AT THE ATLANTIC MINE

is made. It is attached to the bail by projections two and one-half inches in diameter, which pass through holes in the ends of the bail-strap.

When the skip is to stop at any level, a rest is prepared for it, which is removed when it is to pass below. A place is always cut out of the hanging rock for the miners to pass around the shaft. The shaft at this point is a frequent source of accident, from men walking into it, especially at those levels which are little used, and where a signal-man is seldom stationed. They are frequently so stunned by the fall that they become bewildered, and the skip passing up or down strikes and kills them.

The cables which are used for extraction are of iron or steel wire, and are wound around a drum of considerable size. Each level is marked on the rope, or on a tell-tale, where the engineer can see it. The velocity of the skip is regulated by a strap-brake, passing around the revolving drum. It is attached to a long lever of wood on which a man sits, bearing more or less of his weight, according as the velocity is to be greater or less. The skill with which they can regulate it is remarkable. In some mines, especially those with vertical shafts, the skip is allowed to fall with its natural velocity, but is stopped without much jar in a few seconds at the bottom. The cables are greased with coal-tar. As this substance is always acid from the process of refining the petroleum, this greasing often does more harm than good, as it corrodes the strands and weakens the rope. It would be very easy to saturate the acid, by adding lime and boiling before using, as is done in Pennsylvania, but it is not generally done.

The expenses of hoisting, per ton of rock hoisted and milled at the Allouez Mine, for two months of 1876, are given in the tables below:

HOISTING EXPENSES AT THE ALLOUEZ MINE.
JULY, 1876.

	NUMBER OF DAYS' WORK PER TON ROCK.		COST PER TON OF ROCK.	
	Hoisted.	Milled.	Hoisted.	Milled.
Landers and Bellringers, . . .	0.0308	0.0426	$0.0450	$0.0623
Engineers, ...	0.0154	0.0213	0.0308	0.0426
Laborers, ...				
Machinist, ...	0.0029	0.0040	0.0067	0.0094
Fireman, ...	0.0078	0.0108	0.0123	0.0170
Blacksmith and Helper, . . .	0.0057	0.0079	0.0102	0.0141
Repairing Boilers, ...				
Supplies Used, ...			0.1048	0.1450
Total, ...	0.0626	0.0866	$0.2098	$0.2904

August, 1876.

	Number of Days' Work per ton Rock.		Cost per ton of Rock.	
	Hoisted.	Milled.	Hoisted.	Milled.
Landers and Bellringers, . . .	0.0297	0.0405	$0.0440	$0.0600
Engineers, ...	0.0157	0.0214	0.0311	0.0424
Laborers, ...	0.0019	0.0026	0.0029	0.0040
Machinist, ...	0.0028	0.0038	0.0065	0.0089
Fireman, ...	0.0074	0.0101	0.0125	0.0171
Blacksmith and Helper, . . .	0.0055	0.0075	0.0104	0.0142
Repairing Boilers, ...			0.0201	0.0274
Supplies Used, ...			0.1096	0.1496
Total, ...	0.0630	0.0859	$0.2371	$0.3235

The number of tons of rock hoisted was:

	July.	August.
Total rock hoisted, ...	7006 tons.	7273 tons.
Rock sent to stamps, ...	5062 "	5330 "
Poor rock sent to burrows, ...	1944 "	1943 "
Per cent. stamped, ...	72.25	73.28

The total number of tons hoisted from July 1st, 1875, to July 1st, 1876, was 82,410. The number of tons of rock milled was 51,135, or 62.5 per cent. of the rock hoisted.

The front wheels of the skip as it arrives at the top of the tramway of the shaft, fall between the rails, and the contents are dumped on to a grating made of rails. The fine ore, of which there is very little in the conglomerate mines, falls through, while the large pieces slide into the rock-house. Here all the large pieces are broken with sledges, and the poor carried to the burrows, while those sufficiently rich to be treated are carried to the rock-house. The breaking up of the large pieces of conglomerate is a laborious operation when done by hand. To avoid this the rock is sometimes broken by a steam-hammer, as at the Calumet & Hecla. Some mines have a shaft-house for each shaft, which is a bad plan. Others have one for all the shafts; others, still, do no sorting in the shaft-house, but carry all the ore to the rock-house. The rock-house is usually several hundred feet away from the shaft-house, and is connected with it by a trestle-way, and is often at a lower level than the shaft-house. The car carrying the ore is moved automatically by a wire cable; when it arrives at the rock-house it dumps itself, in the same way as the mine-skip, over a grating, and returns to the shaft-house. The ore fine enough to be stamped is discharged at once into pockets. The large pieces are brought to a large-size Blake's crusher, which, at the Atlantic Mill, is sixteen inches by twenty-four inches; the medium ore goes to one fifteen inches by nine inches. The large crusher discharges immediately into the one of smaller size. At the Atlantic Mill, one large and two small crushers break from three hundred and twenty to three hundred and fifty tons of ore per day. On conglomerate rock they would break about half as much. No attempt is made to screen the ore as it comes from the crushers. It is all discharged into bins to go to the stamps. It should be screened, and the material fine enough to pass the stamp-screens separated, so as to allow the stamp to work only on ore needing crushing, for it has been found by experiment in California, and also on Lake Superior, with the Ball stamps, that it takes just as long to discharge the mortar filled with crushed rock as it does to crush the rock and discharge it.

THE NUMBER OF MEN AND TOTAL COST OF ASSORTING AND SELECTING AT THE ALLOUEZ MINE WAS, IN

	JULY, 1876.		AUGUST, 1876.	
	No. of Men.	Cost.	No. of Men.	Cost.
Machinist, ...	⅜	$24 99	⅜	$26 25
Blacksmith, ...	⅞	36 38	1⅛	50 19
Fireman, ...	1	41 34	1	42 57
Foreman, ...	3	195 00	3	195 00
Laborers, ...	39¼	1365 69	42½	1457 48
Total, ...	44½	$1663 40	48	$1771 49

The average monthly force during 1875 was 48 men.

The expenses of sorting and selecting the ore for July and August, 1876, are given in the tables below:

ASSORTING AND SELECTING EXPENSES AT THE ALLOUEZ MINE, JULY, 1876.

	NUMBER OF DAYS' WORK PER TON ROCK.		COST PER TON OF ROCK.	
	Hoisted.	Milled.	Hoisted.	Milled.
Machinist, ...	0.0014	0.0019	$0.0036	$0.0051
Blacksmith, ...	0.0034	0.0047	0.0052	0.0072
Laborers Selecting Rock, . . .	0.1512	0.2093	0.1949	0.2698
Fireman, ...	0.0039	0.0054	0.0059	0.0080
Foreman, ...	0.0116	0.0160	0.0278	0.0385
Supplies Used, ...			0.0537	0.0743
Total, ...	0.1715	0.2373	$0.2911	$0.4029

August, 1876.

	Number of Days' Work per ton Rock.		Cost per ton of Rock.	
	Hoisted.	Milled.	Hoisted.	Milled.
Machinist, ...	0.0014	0.0019	$0.0036	$0.0049
Blacksmith, ...	0.0042	0.0057	0.0069	0.0094
Laborers Selecting Rock, . . .	0.1576	0.2151	0.2004	0.2735
Fireman, ...	0.0037	0.0050	0.0059	0.0081
Foreman, ...	0.0111	0.0151	0.0268	0.0366
Supplies Used, ...			0.0515	0.0703
Total, ...	0.1780	0.2428	$0.2951	$0.4027

The percentage of ore sent to the mills is very variable, depending on the richness of the mine. In 1876, the Quincy stamped 75 per cent. of the rock hoisted, and the Allouez 62.5 per cent.*

By dressing, the mineral is divided into five classes which vary somewhat from mine to mine. No. 1 is barrel-stuff, the other grades come from the washers. The value of these grades is expressed in assay and ingot.

The Atlantic has very little barrel-stuff, and No. 1 from that mine is from the washers.

	Allouez, assay.	Allouez, ingot.	Atlantic, assay.
No. 1, ...	96 per cent.	90 per cent.	98 per cent.
No. 2, ...	94 "	80 "	88 "
No. 3, ...	79 "	60 "	70 "
No. 4, ...	37 "	30 "	35 "
No. 5, ...	40 "	25 "	30 "

The impurity in Nos. 4 and 5 is mostly iron.

Very little of Nos. 4 and 5 is produced. No. 4 is slimes collected from the washing, and No. 5 slimes from the tail-house; they are very impure, containing mostly iron. All of these grades are smelted together. The mineral is not dried, but packed wet in barrels, and goes to the smelting works with the water in it, which is weighed and charged for as copper. The percentage of copper in the rock at the Atlantic in 1876 was 1.3; at the Allouez, 1.4. The average yield of the rock in ingot at the Atlantic was .99 per cent., and at the Allouez .87 per cent. The average yield of the mineral in 1877 was, at the Atlantic, 71.32 per cent.; at the Phœnix, 73.34, per cent., and at the Ridge, 77 per cent. The cost of stamping per ton, in 1877, was $0.578 at the Atlantic, and $0.83 at the Central. In 1875, at the Central, it was $0.87.

The yield of the ore is determined by assay and the returns of ingot copper from the smelting works, and is expressed by so much "mineral," or dressed ore sent to the smelting works, and so much "ingot," or copper, returned from the smelting works. With the exception of the Calumet & Hecla no attempt is made to determine the value of the ore by assay at the mine, but complete confidence is placed in the assays made at the smelting works. For a short time assayers were employed at both the Osceola and the Allouez mines, but the laboratories were abandoned after a very incomplete trial. Every mine, or at least two mines together, should have an assayer, not so much to control the smelting works, whose returns are rarely ever disputed, as to control their own dressing works, and to ascertain in what direction to look for economies and improvements. The only assay now made is the Cornish shovel-assay, which, at the best, gives but the most rudely approximate results, and can only be said to be better than nothing. The method of taking the assay-sample on the shovel allows the greater part of the fine ore to escape. It may be said that it is not possible to save this fine ore, which, by the present method, is very true; but if the exact quantity lost was known, there would be great stimulus to efforts to save it, and it would, at least, lead to improved methods or attempts to improve them. Experiments in this direction can be made at a very small expense.

---

* See p. 298.

The mills must be placed where water can be had in abundance. This has led to two methods: one is to place the mill on the lake and pump the water, as is done in the Calumet & Hecla, Osceola, Quincy, Franklin, and Pewabic mines; the other is to place the mill in a favorable position and bring the water to it in launders, which, in the Atlantic and Allouez mines, are two and one-half miles long. Sometimes, as in the case of the Quincy, the Franklin, and the Pewabic mines, the mines and mills are together; at others, they are at considerable distances apart, and are connected by a mine railroad, which, in the case of the Calumet & Hecla, is eight and one-half miles; the Osceola, eight; the Atlantic, three, and the Allouez, two and one-half miles long.

The cost of transportation over these roads, and of keeping them in repair, is a considerable item. The details of the Allouez Mine for July, 1876, are given below:

Railroad Expenses.

13 Engineers,	$60.00
11 Firemen,	45.00
13 Brakemen,	45.00

The following table gives the cost of the mine railroad per ton of rock hoisted and stamped at the Allouez Mine, for July and August, 1876:

Mine Railroad Expenses at the Allouez Mine,
July, 1876.

	Number of Days' Work per ton Rock,		Cost per ton of Rock.	
	Hoisted.	Milled.	Hoisted.	Milled.
Engineer, ...	0.0039	0.0054	$0.0089	$0.0123
Brakeman, ...	0.0039	0.0054	0.0059	0.0082
Fireman, ...	0.0039	0.0054	0.0070	0.0097
Trackman, ...	0.0207	0.0287	0.0262	0.0363
Supplies Used, ...			0.0213	0.0295
Total, ...	0.0324	0.0449	$0.0693	$0.0960

August, 1876.

	Number of Days' Work per ton Rock.		Cost per ton of Rock.	
	Hoisted.	Milled.	Hoisted.	Milled.
Engineer, ...	0.0042	0.0057	$0.0092	$0.0126
Brakeman, ...	0.0037	0.0050	0.0061	0.0083
Fireman, ...	0.0042	0.0057	0.0069	0.0094
Trackman, ...	0.0037	0.0050	0.0051	0.0070
Supplies Used, ...			0.0219	0.0299
Total, ...	0.0158	0.0214	$0.0492	$0.0671

The cost of breaking and tramming at the Central, where the mine and mill are close together, was, in 1875, $0.15 per ton, and in 1877, was $0.14. The following tables give the expenses of the stamp-mill of the Allouez Mine for July and August, 1876.*

---

* See also the Metallurgical Review, vol. ii, p. 298.

ALLOUEZ STAMP MILL EXPENSES FOR SUPPLIES.

		July, 1876.				August, 1876.			
		Quantities Used per Ton.		Cost per Ton Rock.		Quantities Used per Ton.		Cost per Ton Rock.	
		Hoisted.	Milled.	Hoisted.	Milled.	Hoisted.	Milled.	Hoisted.	Milled.
Wood	at $2.50 per cord,	0.1113	0.1540	$0.2783	$0.3852	0.0979	0.1336	$0.2447	$0.3339
Lard Oil	" 1.25 " gall.					0.0029	0.0040	0.0036	0.0049
Lubricating Oil	" .35 " "					0.0033	0.0045	0.0012	0.0016
Cylinder Oil	" 1.00 " "	0.0137	0.0190	0.0137	0.0190	0.0066	0.0090	0.0066	0.0090
Kerosene Oil	" .25 " "	0.0070	0.0097	0.0017	0.0024	0.0066	0.0090	0.0016	0.0022
Old Dominion Oil	" .65 " "					0.0133	0.0181	0.0086	0.0117
White Lead	" .12 " lb.	0.0014	0.0019	0.0002	0.0003				
Rubber Packing	" .40 " "	0.0028	0.0039	0.0011	0.0015	0.0005	0.0007	0.0002	0.0003
Iron	" .03 " "	0.0286	0.0396	0.0009	0.0012	0.0275	0.0375	0.0008	0.0011
Steel	" .20 " "	0.0014	0.0019	0.0003	0.0004	0.0014	0.0019	0.0003	0.0004
Nails	" 3¾ and 5c "	0.0071	0.0098	0.0003	0.0005	0.0137	0.0187	0.0005	0.0007
Cotton Waste	" .15 per "	0.0042	0.0057	0.0006	0.0008	0.0066	0.0090	0.0010	0.0014
Copper Rivets	" .75 " "	0.0001	0.0001	0.0001	0.0001				
Babbitt Metal	" .40 " "	0.0042	0.0057	0.0017	0.0023	0.0027	0.0037	0.0011	0.0015
Copper Tacks	" .75 " "	0.0001	0.0001	0.0001	0.0001				
Spring Wire	" .50 " "	0.0014	0.0019	0.0007	0.0009	0.0007	0.0010	0.0003	0.0004
Lumber	" 12.00 " M feet	0.0713	0.0987	0.0009	0.0012	0.0687	0.0937	0.0008	0.0011
Wire Cloth				0.0014	0.0019			0.0014	0.0019
Belting				0.0021	0.0029			0.0021	0.0029
Grate Bars (Steel)								0.0007	0.0009
Shovels	" 1.25 each.	0.0008	0.0011	0.0011	0.0015	0.0016	0.0022	0.0021	0.0029
Lace Leather	" 2.50	0.0001	0.0001	0.0004	0.0006	0.0001	0.0001	0.0003	0.0004
Files and Sandpaper				0.0005	0.0008				
Oil Cans	" .30					0.0003	0.0004	0.0001	0.0001
Lamps, Chimneys, and Wicks				0.0003	0.0004			0.0003	0.0004
Water and Sand Pails	" .25	0.0003	0.0004	0.0001	0.0001			0.0001	0.0001
Foundry Bills				0.0534	0.0739			0.0358	0.0488
Lime and Brick								0.0008	0.0011
Brooms	" .25	0.0010	0.0014	0.0002	0.0003	0.0008	0.0011	0.0002	0.0003
Sundries (Blacksmiths' and Carpenters' Supplies,				0.0021	0.0029			0.0039	0.0054
Total				$0.3624	$0.5016			$0.3191	$0.4354

ALLOUEZ MINE.

	Operation of Mill per ton Ore Milled.						Results.				
1875.	Cords Wood Used.	Cost Wood.	Cost Supplies.	Cost Foundry Bills	Wages.	Total Running Expense.	Tons Rock Crushed.	Tons Stamped per Cord Wood.	Pounds Copper Produced.	Per ct. Copper.	No. of Men Empl'd.
July…………	0.2267	$0.5669	$0.1318	$0.2869	$0.7582	$1.7435	2,205	4.40	804.30	1.8	40
August…………	0.2088	0.5219	0.2018	0.0522	0.4635	1.2398	4,096	4.79	1,709.70	2.09	44
September……	0.1684	0.4210	0.0740	0.1226	0.4342	1.0518	4,656	5.90	1,800.50	1.9	49
October………	0.1775	0.4438	0.0678	0.1381	0.5306	1.1804	4,450	5.63	1,700.55	1.9	48
November……	0.1736	0.4340	0.0864	0.1614	0.4838	1.1656	3,600	5.76	1,296.80	1.7	38
December……	0.1467	0.3637	0.0954	0.0852	0.4533	0.9976	4,976	6.91	2,003.50	2.	45
1876.											
January………	0.1967	0.4917	0.0863	0.0915	0.5215	1.1910	4,200	5.08	1,600.54	1.9	48
February…….	0.2480	0.6200	0.0955	0.2649	0.9258	1.9062	2,500	4.03	904.40	1.8	47
March…………	0.1725	0.4312	0.0283	0.0661	0.4332	0.9588	4,812	5.80	1,604.60	1.6	46
April…………	0.1422	0.3555	0.0293	0.0540	0.3161	0.7549	5,295	7.	1,723.23	1.6	40
May…………	0.1655	0.4138	0.0501	0.0750	0.3539	0.8928	5,015	6.	1,801.30	1.8	44
June…………	0.1426	0.3565	0.0529	0.0818	0.3265	0.8177	5,330	7.	1,804.55	1.7	43
Total………	0.1742	$0.4350	$0.0777	$0.1075	$0.4641	$1.0843	51,135	5.74	18,753.97	1.83	532

ALLOUEZ STAMP MILL EXPENSE—LABOR AND SUPPLIES.

JULY, 1876.

	Number of Days' Work per ton Rock.		Cost per ton of Rock.	
	Hoisted.	Milled.	Hoisted.	Milled.
Machinist, ...	0.0096	0.0133	$0.0242	$0.0335
Engineers, ...	0.0087	0.0120	0.0156	0.0217
Firemen, ...	0.0164	0.0227	0.0273	0.0379
Head Runners, ...	0.0082	0.0113	0.0101	0.0140
Stamp Feeders, ...	0.0265	0.0367	0.0383	0.0530
Dressers, ...	0.0655	0.0906	0.0783	0.1082
Cooper and Blacksmith, . . .	0.0038	0.0053	0.0091	0.0125
Watchman, ...	0.0043	0.0060	0.0073	0.0101
Carpenters, ...	0.0053	0.0073	0.0088	0.0122
Supplies Used, ...			0.3624	0.5016
Total, ...	0.1483	0.2052	$0.5814	$0.8047

AUGUST, 1876.

	Number of Days' Work per ton Rock.		Cost per ton of Rock.	
	Hoisted.	Milled.	Hoisted.	Milled.
Machinist, ...	0.0093	0.0127	$0.0237	$0.0323
Engineers, ...	0.0084	0.0114	0.0161	0.0220
Firemen, ...	0.0165	0.0225	0.0278	0.0379
Head Runners, ...	0.0084	0.0114	0.0107	0.0146
Stamp Feeders, ...	0.0269	0.0367	0.0386	0.0527
Dressers, ...	0.0697	0.0951	0.0804	0.1097
Cooper and Blacksmith, . . .	0.0042	0.0057	0.0089	0.0121
Watchman, ...	0.0042	0.0057	0.0068	0.0093
Carpenters, ...				
Supplies Used, ...			0.3192	0.4354
Total, ...	0.1476	0.2012	$0.5322	$0.7262

ALLOUEZ MINE.

	July, 1876.	August, 1876.
Tons of rock stamped per cord of wood, .	6.47	7.47
Cost of stamping ton of rock, ...	$0.8047	$0.726
Average yield of rock stamped in ingot, .	1.819 per cent.	1.685 per cent.
Average yield of rock hoisted in ingot, .	1.31 "	1.24 "
Number of tons of rock hoisted, ...	7006	7237
Number of tons of rock stamped, ...	5062	5330

Average cost of milling one ton of rock, from July 1st, 1875, to July 1st, 1876, $1.0843.

Average cost of mining one ton of rock, delivered in rock-house, during same period, $2.744.

Average cost of one ton of rock, including smelting, $6.613.

The stamps at the Central Mine are of the Cornish patterns. The table below gives some details regarding them:

	1875.	1877.
Number of days run, ...	91	108
Number of stamp-heads run, ...	32	29
Number of tons of rock stamped per head in twenty-four hours, ...	5.87	5.45
Yield of the rock in mineral, . . .	3.78 per cent.	4.21 per cent.
Yield of the mineral in copper, . . .	70.08 "	71.39 "
Number of tons stamped per cord of wood, .	10.27	10.45
Cost per ton of rock stamped, . . .	$0.87	$0.83

The three following tables relate to the expenses of the Atlantic Mine:

ATLANTIC MINE.

	1875.	1876.	1877.
Number of tons of mineral per month, . .	105	111	120
Percentage yield of the mineral, ...		68.85	71.32
Yield of the mineral per ton of rock, . .	27 lbs.	27.56 lbs.	27.3 lbs.
Number of lbs. of ingot copper, ...	1,565,000	1,835,041	2,054,304
Number of cu. fathoms worked per man, .	17.8*	19.67	20.14
Cost per fathom, ...	$55.48†	$52.47	$45.62
Number of men and officers, ...	316	333	352

EXPENSE PER CUBIC FATHOM OF GROUND MINED AT THE ATLANTIC MINE.

	1874.	1875.	1876.	1877.
Total running expenses and marketing, . . .	$62.62	$61.61	$53.10	$47.46
Construction expenses, ...		6.13	.83	1.84
Net expenses of mining and marketing, . . .	$62.62	$55.48	$52.27	$45.62

Ratio of running expenses and cost of smelting and marketing, per ton of rock stamped, at the Atlantic Mine:

	1874.	1875.	1876.	1877.
Smelting and marketing, ...	$0.59	$0.56	$0.56	$0.49
Stamping, ...	1.00	.88	.67	.58
Mine railroad, ...	.16	.15	.12	.117
Mining, breaking, hauling, and officers, .	2.34	2.31	2.19	1.883
Total, ...	$4.09	$3.90	$3.54	$3.07

---

* In 1874, 15.7.

† In 1874, $62.62.

It is interesting to notice the continual decrease in the cost at this mine. The value of a ton of the rock for 1874 and 1875 was $4.39. The mine is working two shafts, each of which has its own rock-house. The copper from a ton of rock, barrelled and ready for delivery, costs 88 cents. This includes the cost of mining and all outside expenses of every kind. The following tables give the surface expenses, the construction account, the miscellaneous expenses, the cost of mining, milling, and the cost of transporting to the smelting works, and smelting at the Allouez Mine, for July and August, 1876:

SURFACE EXPENSES AT THE ALLOUEZ MINE.

JULY, 1876.

	NUMBER OF DAYS' WORK PER TON ROCK.		COST PER TON OF ROCK.	
	Hoisted.	Milled.	Hoisted.	Milled.
Surface Captain, ...	0.0038	0.0053	$0.0143	$0.0198
Teamsters and Laborers, . . .	0.0698	0.0966	0.1091	0.1510
Blacksmith, ...	0.0019	0.0026	0.0043	0.0059
Watchman, ...	0.0048	0.0066	0.0068	0.0094
Carpenter, ...	0.0058	0.0080	0.0090	0.0125
Mason, ...				
Supplies Used, ...			0.0368	0.0509
Total, ...	0.0861	0.1191	$0.1803	$0.2495

AUGUST, 1876.

	NUMBER OF DAYS' WORK PER TON ROCK.		COST PER TON OF ROCK.	
	Hoisted.	Milled.	Hoisted.	Milled.
Surface Captain, ...	0.0037	0.0050	$0.0137	$0.0187
Teamsters and Laborers, . . .	0.0678	0.0925	0.1011	0.1380
Blacksmith, ...	0.0019	0.0026	0.0049	0.0067
Watchman, ...	0.0046	0.0063	0.0066	0.0090
Carpenter, ...	0.0037	0.0050	0.0050	0.0068
Mason, ...	0.0037	0.0050	0.0090	0.0123
Supplies Used, ...			0.0592	0.0808
Total, ...	0.0824	0.1164	$0.1996	$0.2723

CONSTRUCTION ACCOUNT AT THE ALLOUEZ MINE.

JULY, 1876.

	NUMBER OF DAYS' WORK PER TON ROCK.		COST PER TON OF ROCK.	
	Hoisted.	Milled.	Hoisted.	Milled.
Carpenters and Masons on new house, ...	0.0154	0.0213	$0.2459	$0.3403
Laborers at addition to stamp mill, ...				
Carpenters, ...				
Lumber and Supplies for construction of clerks' house, . .				
Total, ...	0.0154	0.0213	$0.2459	$0.3403

AUGUST, 1876.

	Number of Days' Work per ton Rock.		Cost per ton of Rock.	
	Hoisted.	Milled.	Hoisted.	Milled.
Carpenters and Masons on new house, ...				
Laborers at addition to stamp mill, ...	0.0148	0.0202	$0.0195	$0.0266
Carpenters, ...	0.0260	0.0355	0.0510	0.0696
Lumber and Supplies for construction of clerks' house, . .			0.0768	0.1048
Total, ...	0.0408	0.0557	$0.1473	$0.2010

MISCELLANEOUS EXPENSES AT THE ALLOUEZ MINE.

JULY, 1876.

	Number of Days' Work per ton Rock.		Cost per ton of Rock.	
	Hoisted.	Milled.	Hoisted.	Milled.
Agents and Clerks, ...	0.0116	0.0161	$0.0761	$0.1054
Insurance (monthly), ...			0.0214	0.0296
Discount, ...			0.0040	0.0055
Taxes (monthly), ...			0.0571	0.0790
Assay, ...			0.0027	0.0038
Expense in suit, ...			0.0102	0.0141
Travelling expenses, ...				
Supplies used, ...			0.0092	0.0127
			$0.1807	$0.2501
Commission subtracted, .			0.0121	0.0167
Total, ...	0.0116	0.0161	$0.1686	$0.2333

AUGUST, 1876.

	Number of Days' Work per ton Rock.		Cost per ton of Rock.	
	Hoisted.	Milled.	Hoisted.	Milled.
Agents and Clerks, ...	0.0111	0.0151	$0.0733	$0.1000
Insurance (monthly), ...			0.0206	0.0281
Discount, ...			0.0039	0.0053
Taxes (monthly), ...			0.0550	0.0750
Assay, ...				
Expense in suit, ...			0.0245	0.0334
Travelling expenses, ...			0.0034	0.0046
Supplies used, ...				
			$0.1807	$0.2466
Commission subtracted, .			0.0116	0.0158
Total, ...	0.0111	0.0151	$0.1691	$0.2307

TOTAL COST OF MINING AND MILLING AT THE ALLOUEZ MINE.

	JULY, 1876. Cost per ton of Rock.		AUGUST, 1876. Cost per ton of Rock.	
	Hoisted.	Milled.	Hoisted.	Milled.
Total Mining Cost, ...	$2.0395	$2.8227	$2.0571	$2.8070
Hoisting Expense, ...	0.2098	0.2904	0.2371	0.3235
Assorting and Selecting, . . .	0.2911	0.4029	0.2951	0.4027
Surface Expenses, ...	0.1803	0.2495	0.1996	0.2723
Railroad Expense, ...	0.0693	0.0960	0.0492	0.0671
Mineral and Copper Expense, .	0.0268	0.0371	0.0285	0.0389
Miscellaneous Expenses, . . .	0.1686	0.2333	0.1691	0.2307
Stamp Mill Expenses, . . .	0.5814	0.8047	0.5322	0.7262
Construction Account, . . .	0.2459	0.3403	0.1473	0.2010
Total Expenditures, . . .	$3.8128	$5.2770	$3.7152	$5.0696
Received for Teaming Wood, Rents and Sundries, . . .	0.1013	0.1402	0.1141	0.1557
Total, ...	$3.7115	$5.1368	$3.6011	$4.9139

MINERAL AND COPPER EXPENSE AT THE ALLOUEZ MINE.

	JULY, 1876. Cost per ton of Rock.		AUGUST, 1876. Cost per ton of Rock.	
	Hoisted.	Milled.	Hoisted.	Milled.
Mineral Range R. R. Co., for Transportation of Mineral, .	$0.0230	$0.0318	$0.0240	$0.0327
Detroit and Lake Superior Copper Co.—"Coopering," . .	0.0038	0.0053	0.0045	0.0061
Total, ...	$0.0268	$0.0371	$0.0285	$0.0389

The whole number of men in the employ of the Allouez company was in July, 1876, 396, and in August, 417. The following table, giving the details of the Quincy Mine for eight years, is taken from the *Hancock Journal*, of March, 1878.